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## ON THE GROSS ANATOMY OF CAMPELOMA.

BY R. ELLSWORTH CALL.

THE collection of a large number of specimens of *Campelema subsolidum* Anthony, in the Des Moines river, Iowa, in early August, presented opportunities to somewhat carefully study the coarser anatomy of the genus as exhibited in this species. The results of this study are herein given. It may be noted, as introductory, that an unexpected closeness of structure to that of the foreign genus *Paludina* was developed, and, further, that the general diagnosis given by Dr. Stimpson<sup>1</sup> will need some slight emendation, particularly in respect to certain external characters, and in respect to the lingual teeth and the branchial laminae.

*External Characters.*—In the living and recently dead animal the color of the foot-mass is light lead or bluish white. Viewed from above, the cervical lappets, foot, operculigerous lobe, tentacles and proboscis are further enlivened by irregularly scattered bright orange-yellow dots. These dots are, on the tentacles and proboscis, arranged in somewhat regular transverse rows, giving a barred appearance to each. These last-named organs are, moreover, marked by an abundant deposition of black pigment immediately under the cuticular membrane. The under surface of the foot, the crawling disk, shows, in living specimens, the large longitudinal pedal muscles. When these muscles contract, in the act of withdrawal into the shell, the anterior margin of the disk is reflected upwards and backwards over the proboscis and tentacles. This reflected portion is, as a whole, then bent backwards and downwards to be finally covered by the posterior portion of the foot, the upper surface of which carries the operculum. The whole mass is then withdrawn into the shell. During the period of reproduction, when the organs devoted to that function are in a condition of marked activity and distension, the animal, especially of the female, cannot be wholly retracted. In this respect it resembles most of our large *Helices*.

*Sexual Features.*—The sexes are readily distinguished, in life, by means of the right tentacle, which, in the male, is very much larger than its fellow and rather more curved outwards (Plate VII., Fig. 2,

<sup>1</sup> Smithsonian Misc. Coll., No. 144, p. 35, 1865.

and VII. of Fig. 1, in the text). Again, as appears below, the shells differ in certain particulars of corresponding dimensions.

The male seminal duct is displayed throughout nearly its whole length by clipping the mantle along the extreme left of the branchial chamber. The *vas deferens superior* (IV., Fig. 1) arises from a point on the anterior left third of the testis (II., Fig. 1). This

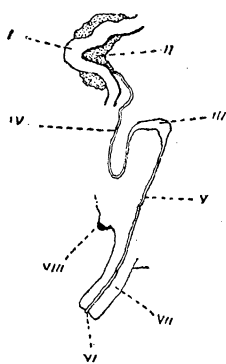


Fig. 1.

latter organ is placed immediately under the right duodenal fold of the intestine (I., Fig. 1). It is about three times longer than wide, and whitish in color. The *vas deferens superior* after passing anteriorly to a point near the anal extremity of the intestine is suddenly bent obliquely backwards and traverses the floor of the branchial chamber for a short distance, but soon turns forward again at a somewhat acute angle. At this point (III., Fig. 1) is the prostate. The *vas deferens inferior* (V., Fig. 1) is rather long, narrow, and nearly straight, and is continued along the floor of the right

tentacle to the verge (VI., Fig. 1). The right tentacle thus becomes an intromittent organ in the process of copulation. This tentacle is somewhat flattened above, presenting, in cross section, an elongated ellipse. It is somewhat less in length than its left fellow, and is rather more curved outwards.

In the gravid female the gestatory sac (Plate VII., Fig. 5, c) occupies the greater portion of the body whorl on the right side. It is readily distinguished in the living specimen by the greater deposit of black pigmentary matter in its thin outer walls. Anteriorly the sac opens into a rather small duct, the mouth of which is prolonged into the branchial chamber about 2 to 2.5 millimetres (b, Plate VII., Fig. 5). This duct is guarded at each extremity by rather powerful sphincter muscles. Anteriorly the walls of the gestatory sac are slightly thicker and are modified into longitudinal folds or rugæ leading towards the duct. These possibly are of use in guiding the extrusion of the young.

During the summer and fall months, and often also in hibernating specimens, the gestatory sac is crowded to distension with young, in various stages of development (Plate VII., Fig. 5, c). Those most anterior are, in early August, nearly or quite through their prenatal growth, and are less closely crowded upon one another

than are those in the rear portion of the sac. All the young in the anterior portion possess shells. The shell of the young at

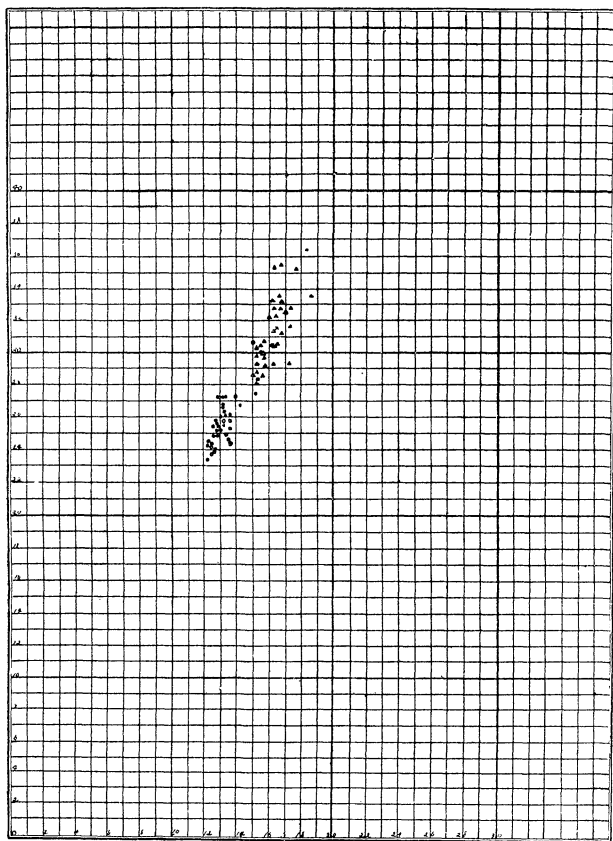


FIG. 2.

this stage is devoid of *colored* epidermis, is crystalline white, and possesses from 2 to  $2\frac{1}{2}$  complete whorls. The apex is very short and blunt, the first whorl being nearly uniform in diameter throughout its length, while the body whorl is very large, comprising fully nine-tenths the entire bulk of the shell. The darker tentacles and the black eyes at their outer base are readily seen through the substance of the shell. The average dimensions of a dozen or more young examined were, for length 3.5 mm., for diameter 2.96 mm. The embryonic whorls never, so far as experience goes with mature specimens with completely preserved apices, acquire the characteristic green epidermal coloring.

The number of young is variable, the large mature specimens containing, as might be expected, the greater number of young shells. Twenty specimens were carefully examined with a view to this feature, with the following result:—

Specimen.	Young.	Specimen.	Young.	Specimen.	Young.	Specimen.	Young.
1	36	6	59	11	29	16	47
2	42	7	52	12	25	17	42
3	51	8	32	13	49	18	64
4	35	9	32	14	58	19	63
5	41	10	38	15	34	20	50

These twenty individuals, therefore, present an average of forty-three young.

Aside from the tentacular differences which exist between the male and female, both tentacles of the latter being uniformly subulate, a further sexual difference appears in the greater size and somewhat more globose character of the female shell. Coördinated with this difference in dimensions is the more shouldered character of the whorls in the female specimen, a difference connected with the position and necessarily large size of the gestatory sac. The males are more regularly conical, with rather less oblique aperture, and are of considerably less globose appearance than are the females. This difference was supposed to be of value in determining the sex when only the shell was at hand. To test it as a sexual differential character, thirty-six of the largest males and an equal number of the largest females were selected from a finding of more than a gallon of *C. subsolidum*, taken on August 6, 1887, and were carefully measured. The results appear in the following:—

TABLE OF DIMENSIONS. MALES.

No.	I.	II.	No.	I.	II.	No.	I.	II.
	mm.	mm.		mm.	mm.		mm.	mm.
1	25.88	12.80	13	24.94	12.92	25	24.22	12.36
2	26.00	13.00	14	24.52	12.38	26	25.14	13.00
3	27.25	13.32	15	26.10	13.51	27	23.90	12.70
4	26.06	13.31	16	30.76	15.00	28	26.62	13.12
5	27.22	12.90	17	27.34	14.00	29	23.94	12.86
6	26.80	13.14	18	24.95	13.36	30	25.84	12.92
7	27.47	15.08	19	27.32	13.04	31	26.16	13.29
8	25.50	12.66	20	26.86	14.20	32	25.16	12.92
9	24.48	12.54	21	25.76	13.62	33	25.50	13.60
10	25.54	12.90	22	25.20	13.61	34	23.36	12.24
11	26.28	13.40	23	24.82	13.50	35	24.95	12.88
12	24.14	12.50	24	28.32	15.22	36	24.00	12.64

I. = length in mm. II. = diameter in mm.

TABLE OF DIMENSIONS. FEMALES.

No.	I.	II.	No.	I.	II.	No.	I.	II.
	mm.	mm.		mm.	mm.		mm.	mm.
1	36.44	18.40	13	35.50	17.72	25	29.20	16.22
2	30.00	15.68	14	30.30	16.29	26	29.10	15.80
3	29.80	15.16	15	32.37	16.40	27	32.88	16.34
4	32.12	16.00	16	30.50	15.56	28	30.24	16.60
5	32.92	16.88	17	28.50	15.68	29	23.94	12.86
6	30.26	16.21	18	33.14	16.80	30	25.84	12.92
7	30.44	15.50	19	29.49	17.32	31	26.16	13.29
8	33.62	18.62	20	30.00	15.50	32	25.16	12.92
9	35.28	17.62	21	31.64	17.36	33	25.50	13.60
10	29.88	15.72	22	33.14	16.16	34	23.36	12.24
11	33.50	16.60	23	35.40	17.32	35	24.95	12.88
12	32.50	17.00	24	30.42	16.56	36	24.00	12.64

I. = length in mm. II. = diameter in mm.

A comparison of ratios shows the numerical values of differences, as follows: Length of male to its diameter,  $\frac{25}{13} \frac{789}{234}$ ; length of female to its diameter,  $\frac{31}{16} \frac{357}{127}$ ; length of female to length of male,  $\frac{31}{25} \frac{357}{789}$ ; diameter of female to diameter of male,  $\frac{16}{13} \frac{127}{234}$ . The differences of lengths is 5.561 and of diameters 2.893. It would appear, then, that this degree of difference may be of diagnostic value in the matter of sex. The diagram, Fig. 3, is designed to present this sexual peculiarity in a graphic form. The marginal numbers represent millimetres. The ordinates represent the lengths, and the abscissas, which have the same scale, represent diameters. The circular conventional sign represents the male and the triangular character the female specimen. The average dimensions of each group are represented by the open conventional sign with its distinguishing sex mark conjoined. It will be seen that while the dots fall into two pretty well-defined groups, the range of greatest variation follows the ordinates, and that this range is comparatively greater for the female than for the male form. In other words, the males are more constant in lengths and vary less in diameter, while, for the female form, differences in length are measurably compensated by corresponding increase in diameter.

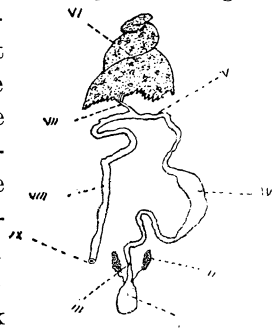


Fig. 3.

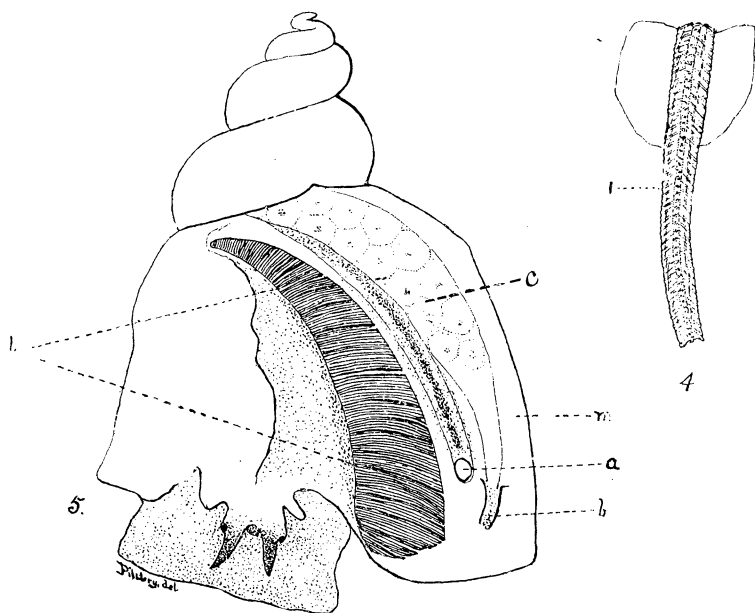
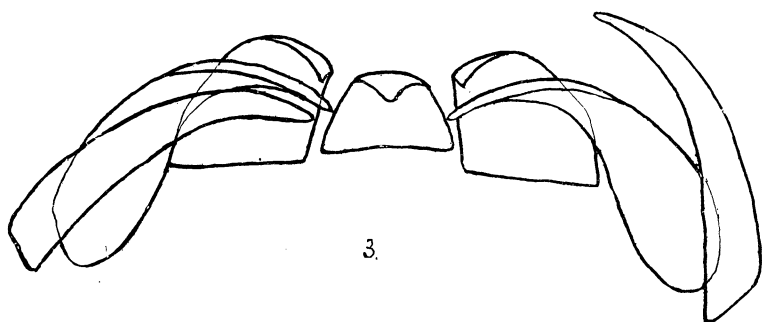
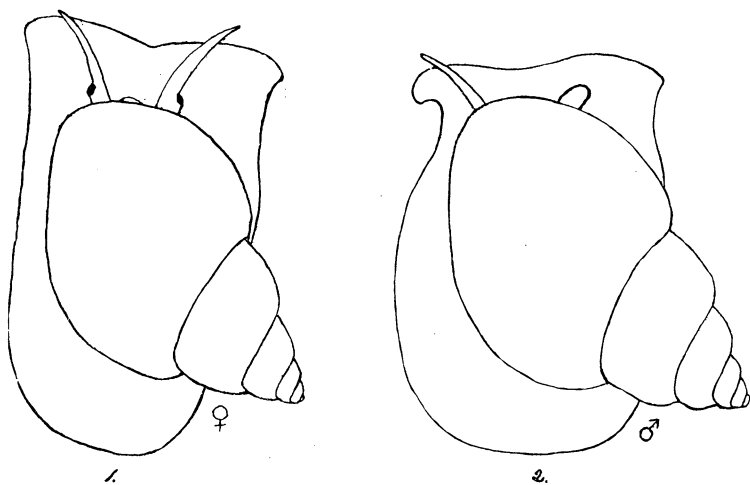
In connection with this character it may not be altogether amiss to call attention to certain so-called species which have been based upon the males of *C. subsolidum*. They are *Campeloma milesii* Lea,

*C. coarctatum* Lea and *C. exilis* Anthony. The same unfortunate cause of synonymy has led, in the genus *Unio*, to the erection of more than a hundred spurious species, in certain cases the females serving as a basis for not less than five specific names. The *form* of a shell in so extremely variable a group is certainly a very misleading character.

*Digestive Organs.*—The buccal cavity opens on the middle side of the rather short proboscis near its base. Near the œsophagus (III., Fig. 3) and upon the floor of the buccal mass lies the radula. This is a small, narrow, chitinous organ, beset with numerous transverse rows of teeth, arranged according to the formula 3.1.3 (Fig. 3, Plate VII., and Fig. 4). The dentition is therefore tænioglossate. On either side, near the posterior end of the buccal cavity, open the ducts of the salivary glands (II., Fig. 3). These are small racemose paired glands, dirty white in color, and lie close upon the œsophagus. Including their ducts, they are about 1.5 mm. in length, and nearly or quite .25 mm. in width. The œsophagus is long, irregularly winding, placed upon the floor of the branchial cavity, and opens, into a somewhat capacious stomach (IV., Fig. 3), near the middle of the whorl next the body-whorl. The intestine is of nearly the same size as the œsophagus, and does not enlarge until the opening of the biliary duct is passed (V. and VII., Fig. 3). At this point it is coiled upon itself to the left, forming what may be called the right duodenal fold, immediately under which lies the testis, as stated above. Turning again to the right, it is there directed forward, becomes slightly enlarged, forming the rectal portion of the intestinal canal (VIII., Fig. 3), which opens into the branchial cavity near the margin of the mantle on the right side (IX., Fig. 3). The liver (VI., Fig. 3) is a very large glandular body, completely filling the first two and a half to three whorls of the shell. Its contents are discharged into the duodenal portion of the intestine near the position of the heart. In color it is orange-red, and is somewhat larger and darker in the male than in the female form. This organ, like all other portions of the animal which lie next the shell, is inversed by a thin membrane, containing pigmentary matter, the membrane itself being a continuation of the mantle.

*Respiratory Apparatus.*—The branchial cavity is large, extending backwards throughout nearly the whole length of the body-whorl. It opens towards the right side, its left margin being just

PLATE VII.





above the base of the left tentacle. The chamber is somewhat less in size in the gravid female than in the male, a fact the explanation of which probably lies in the distension of the gestatory sac and its consequent encroachment upon the branchial space. The chamber narrows rapidly posteriorly, and becomes laterally constricted. From its upper and left side walls is pendant the ctenidium (Plate ? Fig. 5, Br). This organ consists of a single row, containing a great number of thin elongately triangular plates, connected above with the branchial vein. The right edge and lower extremity of each plate is free, and each is constantly bathed with water. The plates become smaller as the rear end of the chamber is reached; they are yellowish white in color, and are furnished with abundant cilia. The blood, which is aerated in these plates, is white.

The attention of students with proper appliances at command is directed to these molluscs in respect to their embryology, nervous system, minute anatomy of the reproductive organs, myology and circulatory system. Only the crudest observations on these points were possible under the conditions which were presented to me, and such facts as were ascertained are repressed in the hope that some other one will be able to complete the work here outlined.

*Explanation of the Plate.*— $\times \frac{4}{3}$ . All the figures, save Fig. 2, are drawn from the female. The mantle is clipped along the left margin of the branchial cavity.

Fig. 1. Female, Fig. 2, male individual.

Fig. 3. A single transverse row of teeth.

Fig. 4. Odontophore, natural size and very greatly enlarged.

Fig. 5. Anatomy of the branchial cavity with related organs.

a. Rectum and anus.

b. The opening of the gestatory sac, c.

br. The ctenidium.

The figures on the plate were drawn by Mr. H. A. Pilsbry from dissections made by him. Those in the text are drawn, somewhat diagrammatically, by the author, from nature.